The Nebular Theory

The nebular theory is an explanation for the formation of solar systems. The word "nebula" is Latin for "cloud," and according to the explanation, stars are born from clouds of interstellar gas and dust. The transition from an undifferentiated cloud to a star system complete with planets and moons takes about 100 million years. According to this theory, our own solar system formed about 4.6 billion years ago, and others are forming today in distant nebulae.

What the Theory Explains

As it relates to our own solar system, the nebular theory explains three observable facts. The first is that the planets all rotate in the same direction. The second is that they all orbit within 6 degrees of a common plane. The third is that all the terrestrial planets, which are those within the orbit of the Asteroid Belt, are rocky, while those outside it are gaseous. The theory also explains the existence of the Kuiper Belt -- a region on the fringes of the solar system with a high concentration of comets.

A Star Is Born

According to the nebular theory, a solar system begins when an interstellar cloud, containing approximately 75 percent hydrogen, 25 percent helium and traces of other elements, begins to form areas of higher concentration, or clumps. As the clumps grow, gravitational forces increase and get converted to the kinetic energy of the increasingly fast-moving particles, which collide with one another and generate heat. Eventually one clump dominates, and when its temperature reaches 10 million degrees Kelvin (18 million degrees Fahrenheit), nuclear fission begins. The outward pressure created by the fission reactions prevents further collapse, and the clump of burning hydrogen gas stabilizes and becomes a star.

Seeds of Planets

As a proto-star grows in size, the gases in the nebula from which it is born form a disk and spiral more and more quickly around its center. Eventually, elements on the fringe of the disk begin to form into globules with compositions that depend on their distance from the center. At smaller distances, where temperatures are higher, they are formed of heavy elements, while at greater distances they are formed of ices of water, methane and ammonia. These globules collide with each other and stick together to form larger, spherical bodies in a process called accretion. The larger bodies, with diameters of a few kilometers, are called planetesimals.

Planets and Comets

Once planetesimals form, collisions continue, but they tend to be destructive, and only the largest planetesimals survive. These continue to grow by assimilating surrounding material, including smaller planetesimals, to become planets. The composition of planets closer to the center of the system differs from that of those farther away. The planets within a critical distance, where temperatures are warmer, are rocky, while those beyond the critical distance have solid cores and thick, gaseous atmospheres. At the fringes of the solar system, where gravitational forces are weak, planetesimals never coalesce into planets. These icy bodies sometimes wander in eccentric orbits, and when they get close to the sun, we know them as comets.